Removal of emerging pollutants in conventional and microalgae based biotechnology urban wastewater treatment plants

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INTRODUCTION

Emerging Contaminants are a myriad of trace organic compounds including prescription and over-the-counter pharmaceuticals, veterinary, personnel care products like cosmetics, sunscreens and fragrances [1]. One of the biggest contributors of pharmaceuticals in the environment are wastewater treatment plants (WWTPs) [2]. The removal of some pharmaceuticals in conventional wastewater treatment plants is rather low due to their high solubility and low biodegradability [3]. Microalgae biotechnology offers an interesting solution to tertiary treatments due to the ability of use inorganic nitrogen and phosphorus as well as their capacity to remove heavy metals and some organic chemicals [4].

Emerging pollutants studied

Pharmaceutically Active Compounds (PhACs)

- Analgesics & antiinflamatories
- Antihypertensives
- Lipid Regulators
- Psychiatric drugs
- Antibiotics
- Others

Experimental technologies

Upflow Anaerobic Sludge Blanket (UASB)

- Useful volume: 20 m³
- HRT: 14.6 – 18 hours

High Rate Algae Pond (HRAP)

- Useful volume: 9 m³
- HRT: 6 - 7 days

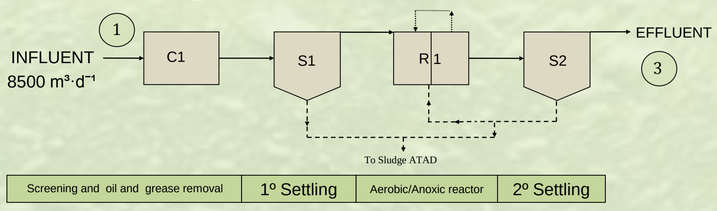
HOW DO THEY REMOVE PhACs?

OBJECTIVE

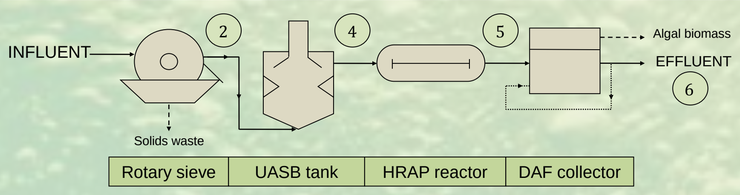
The main objective of this work is to **quantify** and **compare** the removal of pharmaceuticals (n=81) using **conventional** and **microalgae based treatment** technologies in **outdoor large pilot scale**.

MATERIAL & METHODS

Figure 1: WWTP monitored



The **conventional** Municipal WWTP, *El Torno*, is located in **Chiclana de la Frontera** (Spain) (36°25'38"N 6° 9'21"W), serves a population of **45000 equivalent inhabitants** and actually treats an average flow rate of **8500 m³· d⁻¹** .



The **non conventional** WWTP, was a pilot scale installation located in the WWTP El Torno. This experimental treatment process **(ALL-GAS Project)** consist of **three UASB** operated at ambient temperature followed by **six HRAP** that treat an average flow rate of **9 m³·d⁻¹**.

Monitoring program

FEBRUARY ⇩ **JULY** **2015**

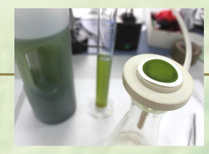
Time-integrated sampling was started at different times of the day in the six sampling points (figure 1) to approximately compensate for the HRT of each treatment step.

During sample collection, ice gel box was placed on auto-sampler to prevent degradation. The same day of sample collection water samples (700 mL) were filtered through Whatman GF/C glass fiber filters (0.45 µm pore size).

600 mL of filtered sample were destined to pharmaceuticals analysis while 100 mL of filtered and 100 mL of non filtered sampled were used for conventional wastewater characterization analysis; Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Nitrogen (TDN) and Total Dissolved Phosphorous (TDP).

Sample preparation and analytical method

TSS

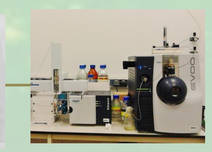


[5] APHA, AWWA, WPCF (2008) – Gravimetric analysis

COD
TDN
TDP

[6] Köthe & Bitsch (1992) – Colorimetric analysis

PhACs



[7] Baena-Nogueras et al. (2016) – Solid Phase Extraction & UPLC-MS/MS

RESULTS & DISCUSSION

	Chemical Oxygen Demand (COD)	Total Suspended Solids (TSS)	Total Dissolved Nitrogen (TDN)	Total Dissolved Phosphorus (TDP)
Influent (mg·L⁻¹)	697 ±176.2	230 ±85.8	44 ±4.6	4 ±1.5
Conventional (% Removal)	92 ±1.9	92 ±2.9	25 ±14.8	70 ±11
UASB (% Removal)	49 ±10.6	32 ±29.4	12 ±18.7	7 ±11.4
HRAP (% Removal)	63 ±29.2	0 ±0	61 ±26.9	48 ±30.6
DAF (% Removal)	78 ±12.2	59 ±51.5	75 ±19.9	85 ±10.5

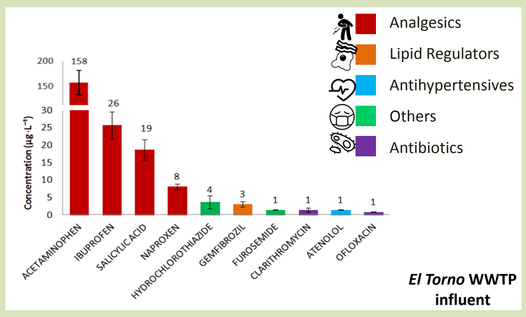
Acronyms

Analgesics
- **APAP** Acetaminophen
- **DIC** Diclofenac
- **IBU** Ibuprofen
- **KPF** Ketoprofen
- **NPX** Naproxen
- **SA** Salicilic Acid

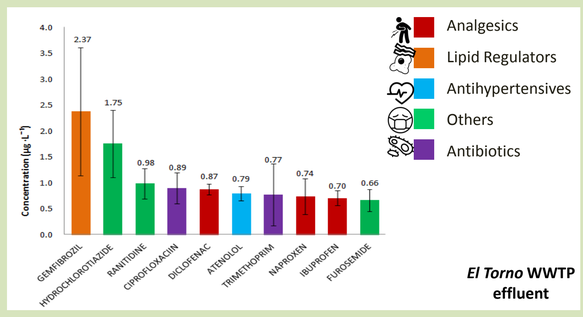
Psychiatric drugs
- **AMT** Amitriptiline
- **CBZ** Carbamazepine
- **FLX** Fluoxetine

Sampling Points
- **INF** Conventional Influent (1)
- **UASB** Upflow Anaerobic Sludge Blanket (4)
- **HRAP** High Rate Algae Pond (5)
- **DAF** Dissolved Air Flotation (6)
- **EFF** Conventional Effluent (3)

INFLUENT average concentration of top 10 PhACs in conventional WWTP *El Torno*

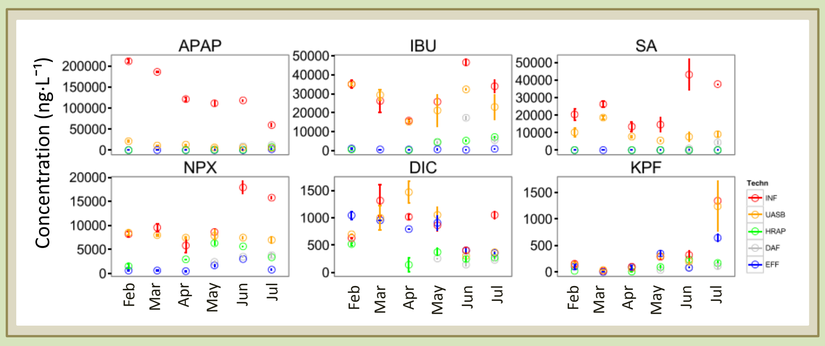


EFFLUENT average concentration of top 10 PhACs in conventional WWTP *El Torno*

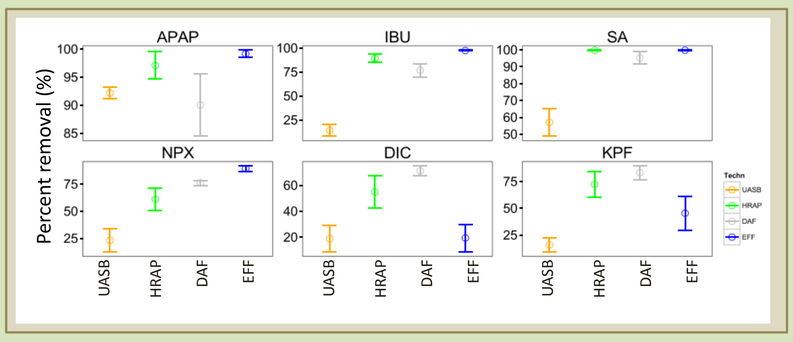


Analgesics & antiinflammatories

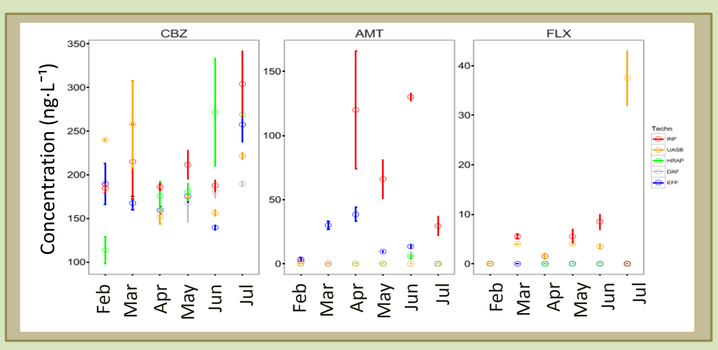
CONCENTRATION IN WASTEWATER

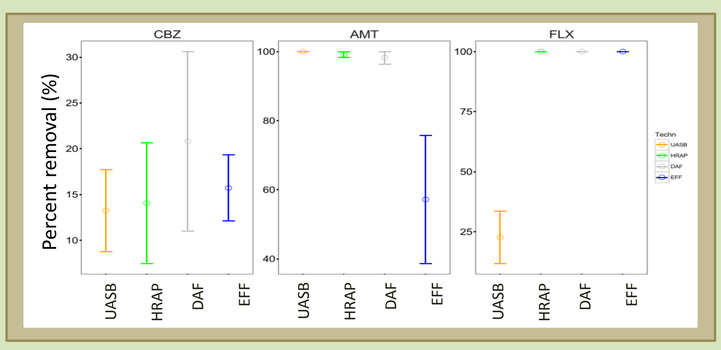


REMOVAL EFFICIENCY



Psychiatric drugs





The group with higher concentration in the WWTP influent is “analgesics & antiinflammatories”. Seasonal variations in some chemicals such as APAP (decreases in summer) or SA (decreases in winter) has been observed.

Although more than 75% of COD was reduced in both, conventional and experimental WWTPs, only between 20 to 60% of five pharmaceuticals groups including antihypertensives, lipid regulators, psychiatric drugs, antibiotics and others were removed.

CONCLUSIONS

1. Both processes (conventional and non conventional) have a similar PhACs removal percentage (>90%). Nevertheless, there are significant differences in the removal of specific PhACs. Some analgesics & antiinflammatories presented removal percentages as high as 95% while some psychiatric drugs show removal percentages as low as 10%.
2. Depending on the chemical , the removal capacity using conventional wastewater treatment can be equal (Salicilic Acid), higher (Naproxen) or lower (Diclofenac) than using UASB and microalgae biotechnologies.
3. Further in-depth studies on the pharmaceutical removal using microalgae technology must be performed to determine the specific removal mechanisms for selected target compound (sorption, photolysis, biodegradation, bioaccumulation…).

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